The association between socioeconomic status and joint replacement of the hip and knee: A population-based cohort study of older adults in Tasmania

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This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/imj.15066

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Acknowledgements

This study was conducted as part of the Tasmanian Older Adult Cohort Study (TASOAC) which was supported by the National Health and Medical Research Council of Australia (NHMRC Grant ID- 302204); Tasmanian Community Fund (Grant ID- D0015018); Masonic Centenary Medical Research Foundation; Royal Hobart Hospital Research Foundation; and Arthritis Foundation of Australia (Grant ID – MRI06161). SL Brennan-Olsen was supported by a NHMRC Career Development Fellowship (1107510). Funding bodies did not have any input at any stage of the conduct of this study, data analysis, interpretation of data or writing of the manuscript. We thank the participants who made this study possible.

Word count: Abstract – 250 (limit: 250), Text - 2467 (limit: 3000)

Key words: socioeconomic status, osteoarthritis, total hip replacement, total knee replacement, Australia

Author contributions

i) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work;

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ii) Drafting the work or revising it critically for important intellectual content;

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iii) Final approval of the version to be published;

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iv) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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INTRODUCTION

Total joint replacement (TJR) is a common and cost-effective procedure performed predominantly for severe, end-stage osteoarthritis (OA) and has been shown to be highly effective in alleviating pain and dysfunction[1, 2]. In Australia, 47,972 total hip replacements

(THR) and 63,854 total knee replacements (TKR) were performed in 2017, and these numbers are predicted to increase[3] with the ageing of the population[4].

Owing to the direct and indirect costs associated with TJR and the availability and use of private health insurance, it is possible that utilization/rates and time to these procedures may differ by socioeconomic variation in populations[5]. Yet, several Australian and international studies have shown mixed evidence on the associations between socioeconomic status (SES) and TJR[1, 2, 4-14]. The majority of these studies are cross-sectional analyses of registry or administrative data for participants who underwent TJR[1, 6]. They mostly assess the utilization/rates of TJR, which may be primarily driven by risk factors rather than SES. In contrast, time to TJR may be mostly dependent on SES over and above the known risk factors. Interestingly, only one study conducted in Canada has examined the time to TJR in a population-based cohort[9].

It is known from prior studies that conducting surgery earlier is associated with better postoperative clinical outcomes[15]. Hence, it is important to identify whether SES is associated with time to TJR in prospective studies, particularly in Australia. Therefore, this study aimed to describe the relationships between SES and time to THR and TKR due to OA in community-dwelling older adults.

MATERIALS AND METHODS

Study population

This study was conducted as a part of the Tasmanian Older Adult Cohort Study (TASOAC), which is a prospective, population-based study primarily aimed at examining the causes and progression of OA. Participants aged between 50-80 years were selected using sex-stratified random sampling from the electoral roll in Southern Tasmania (population 229,000). Participants were excluded if they had any contraindication to Magnetic Resonance Imaging (MRI) or were living in a nursing home. Data collection was undertaken at baseline (n=1,099) between March 2002 and September 2004 (response rate 58%, 1099/1904). Ethical approval was obtained from the Southern Tasmanian Health and Medical Human Research Ethics Committee. The study has been performed in accordance with the ethical standards laid down in the Declaration of Helsinki of 1975, as revised in 2000 and written informed consent was obtained from all participants.

Primary (first-time) total hip and knee replacement

Incident primary THR and TKR were determined by data linkage to the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR), between 1 March 2002 and 21 September 2016. The data collection for AOANJRR in Tasmania started in September 2000 and is collected from both public and private hospitals; data validation is performed using a sequential multi-level matching process with State and Territory Health Department data[3]. Matched data included the type (primary or revision), date, side (left/right) and the reason for the procedure (e.g. OA, fracture, osteonecrosis, inflammatory arthritis, tumour)[16]. In this study, only primary TJR due to OA were included, and there were 3 uni-compartmental knee replacements. Of 1099 participants, 1068 were included in the THR models due to the exclusion of THR due to prior THR and missing data while 1072 participants were included in the TKR models due to the exclusion of prior TKR and missing data (Supplementary Figure 1).

Socioeconomic Status

Area-level SES was ascertained by matching each participant's residential address at baseline to the corresponding Australian Bureau of Statistics (ABS) Census Collection District. The ABS software was then utilized to determine the Socio-Economic Indexes for Areas (SEIFA) values from the 2001 census. SEIFA constitutes of four separate indices, obtained using different variables which summarizes the characteristics of residents within an area (~250 households), thereby providing a single measure to rank the level of advantage and/or disadvantage at the area-level, not of the person. In this study, we employed the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD), which is a measure that incorporates variables such as household income, car ownership, number of one-parent families and educational attainment[17]. The IRSAD scores were analysed in two ways; 1) categorised into quartiles, with quartile 1 representing the most socioeconomically disadvantaged group, 2) dichotomized the cohort at the lowest quartile to compare the most disadvantaged group with the rest of the participants.

Potential confounders

Body mass index (BMI) was measured using objective weight and height measures and steps/day using pedometers[16]. Knee and hip x-rays were performed at baseline and individually scored for osteophytes and joint space narrowing. Prevalence of radiographic OA (ROA) was then defined as 0 or 1[16]. Knee pain was assessed using the Western Ontario McMaster Universities Osteoarthritis Index (WOMAC)[18]. Age, sex, presence of hip pain, number of comorbidities, smoking, and history of knee surgery (other than TJR) were self-reported[16].

Statistical analysis

Baseline characteristics of the population by SES quartiles were described using means and standard deviations or percentages where appropriate.

The association between baseline SES groups and the time to THR and TKR was estimated using Cox proportional hazards models. All the multivariable models were adjusted for baseline age, sex and BMI. Since pain and ROA are the main indications for TJR[19], further mediation analyses were conducted adjusting for presence of hip pain and hip ROA at baseline for the THR models and WOMAC pain and presence of knee ROA for the TKR models in order to assess if the relationships between SES and TJR were independent of pain and ROA[16]. Other potential confounders considered were smoking, comorbidities and history of knee surgery; however, these were excluded from the final models as they did not change the hazard ratio by at least 10%. The assumptions for proportional hazards for all the models were assessed using Schoenfeld residuals. Additionally, linear trends were assessed across SES quartiles.

Further analyses were conducted comparing the participants in the most disadvantaged SES quartile with those in the less disadvantaged SES quartiles (quartiles 2,3 & 4) with and without adjustments for the variables mentioned above.

In an attempt to explore whether the time from moderate-severe pain onset to TJR varied by SES we performed a sensitivity analysis including only those participants at baseline that had moderate-severe knee pain for the TKR models or hip pain for the THR models.

To address any potential bias due to missing data, we conducted further sensitivity analyses using multiple imputation by chained equations (MICE), assuming that the data were missing at random (MAR). 197 participants had missing data (knee ROA, n=80; WOMAC pain, n=3; hip pain, n=10; hip ROA, n=160; IRSAD scores, n=26). Participants with missing data were older, compared to those without missing data. A total of 20 imputed datasets were created, and the results from the analysis of imputed datasets were combined to obtain a single estimate.

A p-value of < 0.05 (two-tailed) was regarded as statistically significant. All statistical analyses were performed on Stata/SE V.15.1 for Mac (StataCorp LP, Texas, USA).

RESULTS

The median follow-up period of the cohort was 12.9 years (interquartile range; 12.2, 13.9). There were 56/1069 participants (5%) who had a THR and 79/1072 participants (7%) who had a TKR (Table 1). Nearly 51% of the participants were women. Baseline age, BMI, the prevalence of knee ROA, the prevalence of hip pain, WOMAC pain and prevalence of comorbidities were different between SES quartiles, in which the most disadvantaged group demonstrated consistently greater values.

For THR and TKR, no statistically significant associations between SES quartiles were observed in unadjusted or adjusted analyses, nor were any trends detected (Tables 2 and 3). In those with pain at baseline, SES quartiles were not associated with time to THR (Supplementary Table 1) or TKR (Supplementary Table 2).

Further analyses showed that, compared with participants in the most disadvantaged SES quartile, those in less disadvantaged SES quartiles (quartiles 2, 3 and 4) were less likely to have a THR in the unadjusted model and the model adjusted for age, sex and BMI (all $p \leq 0.05$). These associations were attenuated when further adjusted for hip pain and hip ROA (Table 4). However, no associations were observed for the time to TKR with SES in the unadjusted or adjusted models in these further analyses (Table 5).

Examination of Schoenfeld residuals showed that the proportional hazards assumptions were reasonable (Data not shown). The results of the sensitivity analyses that used MICE to account for missing data were similar with no changes to the inference when compared to the complete case analysis (Data not shown).

DISCUSSION

This prospective cohort study describes the relationships between SES and time to THR and TKR in community-dwelling older adults, over an average follow-up of 12 years in Tasmania, Australia. The results show that less disadvantaged participants were less likely to have a THR compared to the most disadvantaged participants (i.e. less disadvantaged participants had a longer time to THR compared to the most disadvantaged participants). However, this association was attenuated after further adjusting for hip pain and hip ROA, suggesting that the observed association was mediated by these factors. Taken together, these suggest that in fact, participants are treated according to their symptoms or need rather than their SES, potentially indicating reductions in expected disparity between SES and time to TJR in hip and knee.

Given that the most disadvantaged group had a greater prevalence of pain, and that the association observed in the further analyses between less disadvantaged participants and time to THR attenuated after adjustments for hip pain and ROA, it appears that participants have been treated based on their symptoms or need, irrespective of their SES. While no studies have been conducted on time to THR in Australia, previous cross-sectional studies focusing on the utilization/rates of THR across SES categories also reported no significant differences[1]. However, the authors reported a non-significant U-shaped pattern of THR across the SES groups, where both the most disadvantaged and least disadvantaged groups appeared to have a higher utilisation of THR[1]. In contrast, another Australian study found that people living in most disadvantaged areas were less likely to have a THR[7], and a recent study showed higher rates of THR for most advantaged group[6]. Differences in SEIFA indexes in various time periods[5] may contribute to these divergent findings in the literature. Furthermore, several reports from Sweden[10], Canada[11], United States[12] and Italy[13] have shown considerable discrepancy in the utilisation of THR across the SES gradient[8]. Indeed, the associations of SES with THR between different countries may be dissimilar, owing to the differences in healthcare systems[1].

We did not observe any association between SES categories and time to TKR. Although no reports exist on time to TKR with regard to SES in Australia, a prior Australian study assessing the utilisation of TKR showed no relationship for women, however, found that men in the most disadvantaged group were less likely to undergo TKR, in comparison to less disadvantaged men[2]. A few other Australian studies also showed lower[5, 7], or higher rates[6] of TKR for the most socioeconomically advantaged group. These differences in rates of TKR could be attributed to slight differences in the characteristics included within SEIFA indexes across different time periods[5]. Similar to Australian studies, conflicting evidence has been reported in several international studies[12, 14] potentially because of the differences in the structure of the healthcare systems[1].

Both public and private healthcare providers deliver services in Australia[5]. Access to private healthcare is dependent on having greater financial resources, such as private health insurance and higher income. Hence, most socioeconomically disadvantaged groups usually would utilise public health services[1]. It is likely that the waiting times are much longer in public healthcare facilities than in private facilities[1]. However, the finding that there may be no disparity between SES and time to TJR in this study could be due to several reasons.

The Department of Health and Human Services (DHHS) in Tasmania has implemented several policies such as 'Tasmania's Elective Surgery Access Policy'[20] and 'Tasmania's Elective Surgery Improvement Plan'[21] to manage waiting lists and to improve the equity of access to elective surgeries (e.g. TJR) by ensuring the timeliness of surgeries based on the clinical urgency/need. In instances where the public hospitals may not have the capacity to cater to the higher demand of these surgeries, the DHHS considers redirecting patients to private hospitals appropriately, in order to ensure the timeliness of surgeries for patients in the waiting lists[20]. The treatment costs related to the surgeries are covered by the DHHS[20]. These policies may ensure that the patients are treated according to the need rather than their SES.

Additionally, in Australia, health insurance reforms were instigated in 1999-2000, with government rebates, which had led to an increase of private health insurance utilization from 38% in 1998, to 51% in 2001[22]. Furthermore, AOANJRR reports that the rates of TJR have increased over the years in private healthcare facilities[23]. Similarly, Hanchate et al., 2015 also showed increased utilization of TJR following the introduction of health reforms in specific subpopulations in the state of Massachusetts, United States[24]. Hence, it is possible that the waiting times in public healthcare facilities were reduced, resulting in reduced time to TJR, as more people who obtained private insurance may be attracted to private healthcare facilities.

Furthermore, people with higher SES have greater choice to undertake TJR due to having higher health literacy, financial as well as personal resources with greater supportive networks which may facilitate accessing conservative management strategies such as physiotherapy[25]. They may also have better coping mechanisms and the ability to bring about lifestyle changes with flexible work-related activities and early retirement[5, 8]. These may strikingly delay the need for TJR. Diversely, the limited health literacy, personal resources and weaker coping strategies observed in people with lower SES may facilitate the health-seeking behaviour and accessing healthcare for surgical treatments reducing the time to TJR[5, 8]. Altogether, these may explain the lack of disparity between SES and time to TJR.

There are several strengths to this study. First, this is a prospective study of population-based older adults randomly selected from the community, which makes it generalisable to the Southern Tasmanian population. Second, incident TJRs were ascertained from a comprehensive national registry over the study period from 2002 to 2016, which has the most complete data on TJR in Australia. Third, the SES of each participant was determined by an area-level index which is an aggregate of several parameters of SES obtained from the Australian census. However, there are a few limitations to this study. These results may not be directly applicable to other regions of Australia or the country as a whole, due to the use of area-specific socioeconomic indexes and the unique health provisions provided in Tasmania. We did not have information on personal-level factors such as willingness/perception on TJR or physician-level factors including physicians' perception on the patients and referral patterns, which may play a role in the time to TJR. Furthermore, information on insurance usage was not available. It is also possible that SES may have an impact at the time between moderate/severe symptom onset to surgery. In an attempt to explore this, we performed a sensitivity analysis including only those participants at baseline that had moderate-severe knee pain for the TKR models or hip pain for the THR models. These results corroborated our main study findings, showing no association between SES and time to TJR. Additionally, the TASOAC cohort is predominantly comprised of Caucasians; hence we were unable to assess any ethnic/cultural differences that may affect the time to TJR.

CONCLUSION

The findings of this study suggest that the time to TJR is determined according to the need or symptoms of the participants rather than their SES, indicating reductions in the expected disparity between SES and time to TJR in hip and knee. It also suggests the potential effectiveness of national and state-wide reforms to improve equity in access to TJR surgery.

Acknowledgements

This study was conducted as part of the Tasmanian Older Adult Cohort Study (TASOAC) which was supported by the National Health and Medical Research Council of Australia (NHMRC Grant ID- 302204); Tasmanian Community Fund (Grant ID- D0015018); Masonic Centenary Medical Research Foundation; Royal Hobart Hospital Research Foundation; and Arthritis Foundation of Australia (Grant ID – MRI06161). SL Brennan-Olsen was supported by a NHMRC Career Development Fellowship (1107510). Funding bodies did not have any input at any stage of the conduct of this study, data analysis, interpretation of data or writing of the manuscript. We thank the participants who made this study possible.

REFERENCES

1 Brennan SL, Stanford T, Wluka AE, Henry MJ, Page RS, Graves SE, *et al.* Cross-sectional analysis of association between socioeconomic status and utilization of primary total hip joint replacements 2006–7: Australian Orthopaedic Association National Joint Replacement Registry. *BMC Musculoskelet Disord*. 2012; **13**: 63.

2 Brennan SL, Stanford T, Wluka AE, Page RS, Graves SE, Kotowicz MA, *et al.* Utilisation of primary total knee joint replacements across socioeconomic status in the Barwon Statistical Division, Australia, 2006–2007: a cross-sectional study. *BMJ Open*. 2012; **2**: e001310.

3 Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR). Hip, Knee & Shoulder Arthroplasty: 2018 Annual Report. Adelaide: AOA, 2018. https://aoanjrr.sahmri.com/documents/10180/576950/Hip%2C%20Knee%20%26%20Shoulder%20Arthroplasty (accessed Sep 2019).

4 Bohensky MA, Ackerman I, DeSteiger R, Gorelik A, Brand CA. Lifetime risk of total knee replacement and temporal trends in incidence by health care setting, socioeconomic status, and geographic location. *Arthritis Care Res (Hoboken)*. 2014; **66**: 424-31.

5 Brennan SL, Lane SE, Lorimer M, Buchbinder R, Wluka AE, Page RS, *et al.* Associations between socioeconomic status and primary total knee joint replacements performed for osteoarthritis across Australia 2003–10: data from the Australian Orthopaedic

Association National Joint Replacement Registry. *BMC Musculoskelet Disord*. 2014; **15**: 356.

6 Brennan-Olsen S, Vogrin S, Holloway KL, Page RS, Sajjad MA, Kotowicz MA, *et al.* Geographic region, socioeconomic position and the utilisation of primary total joint replacement for hip or knee osteoarthritis across western Victoria: a cross-sectional multilevel study of the Australian Orthopaedic Association National Joint Replacement Registry. *Arch Osteoporos*. 2017; **12**: 97.

7 Dixon T, Urquhart DM, Berry P, Bhatia K, Wang Y, Graves S, *et al.* Variation in rates of hip and knee joint replacement in Australia based on socio-ec onomic status, geographical locality, birthplace and indigenous status. *ANZ J Surg*. 2011; **81**: 26-31.

8 Ackerman IN, Busija L. Access to self-management education, conservative treatment and surgery for arthritis according to socioeconomic status. *Best Pract Res Clin Rheumatol*. 2012; **26**: 561-83.

9 Hawker GA, Guan J, Croxford R, Coyte PC, Glazier RH, Harvey BJ, *et al.* A prospective population-based study of the predictors of undergoing total joint arthroplasty. *Arthritis Rheum*. 2006; **54**: 3212-20.

10 Wetterholm M, Turkiewicz A, Stigmar K, Hubertsson J, Englund M. The rate of joint replacement in osteoarthritis depends on the patient’s socioeconomic status: A cohort study of 71,380 patients. *Acta Orthop*. 2016; **87**: 245-51.

11 Hawker GA, Wright JG, Glazier RH, Coyte PC, Harvey B, Williams JI, *et al.* The effect of education and income on need and willingness to undergo total joint arthroplasty. *Arthritis Rheum*. 2002; **46**: 3331-9.

12 Hawkins K, Escoto KH, Ozminkowski RJ, Bhattarai GR, Migliori RJ, Yeh CS. Disparities in major joint replacement surgery among adults with Medicare supplement insurance. *Popul Health Manag*. 2011; **14**: 231-38.

13 Agabiti N, Picciotto S, Cesaroni G, Bisanti L, Forastiere F, Onorati R, *et al.* The influence of socioeconomic status on utilization and outcomes of elective total hip replacement: a multicity population-based longitudinal study. *Int J Qual Health Care*. 2006; **19**: 37-44.

14 Skinner J, Zhou W, Weinstein J. The influence of income and race on total knee arthroplasty in the United States. *J Bone Joint Surg Am*. 2006; **88**: 2159.

15 Fortin PR, Penrod JR, Clarke AE, St-Pierre Y, Joseph L, Belisle P, *et al.* Timing of total joint replacement affects clinical outcomes among patients with osteoarthritis of the hip or knee. *Arthritis Rheum*. 2002; **46**: 3327-30.

16 Munugoda I, Wills K, Cicuttini F, Graves S, Lorimer M, Jones G, *et al.* The association between ambulatory activity, body composition and hip or knee joint replacement due to osteoarthritis: a prospective cohort study. *Osteoarthritis Cartilage*. 2018; **26**: 671-79.

17 Australian Bureau of Statistics. Census of population and housing: Socio-Economic Indexes for Areas, 2001. Canberra, Australia: ABS, 2003 Contract No.: 2039.0.

18 Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. *J Rheumatol*. 1988; **15**: 1833-40.

19 Gademan MG, Hofstede SN, Vliet Vlieland TP, Nelissen RG, Marang-van de Mheen PJ. Indication criteria for total hip or knee arthroplasty in osteoarthritis: a state-of-the-science overview. *BMC Musculoskelet Disord*. 2016; **17**: 463.

20 Department of Health and Human Services. Improving time to treatment. Tasmania's Elective Surgery Access Policy Framework. DHHS, 2015 Under Review. https://www.dhhs.tas.gov.au/__data/assets/pdf_file/0020/60176/Improving_Time_to_Treatment_-_Tasmania_s_Elective_Surgery_Access_-_DHHS_Wide_-_THOs_-_Policy_-_200911201_-_UNDER_REVIEW.pdf (accessed Sep 2019).

21 Department of Health and Human Services. Tasmania's Elective Surgery Improvement Plan. DHHS, 2008. https://www.dhhs.tas.gov.au/__data/assets/pdf_file/0019/60175/DHHS_Elective_Surgery_Full_081215.pdf (accessed Sep 2019).

22 Australian Bureau of Statistics. Private Health Insurance: A snapshot, 2004-05. Canberra: ABS, 2006. Report No.: 4815.0.55.001. https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4815.0.55.001Main+Features12004-05?OpenDocument# (accessed Sep 2019).

23 Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR). Hip & Knee Arthroplasty - Annual Report 2011. Adelaide: AOA, 2011. Report No.: 1445-3657. https://aoanjrr.sahmri.com/documents/10180/44800/Annual+Report+2011 (accessed Sep 2019).

24 Hanchate AD, Kapoor A, Katz JN, McCormick D, Lasser KE, Feng C, *et al*. Massachusetts health reform and disparities in joint replacement use: difference in differences study. *BMJ*. 2015; **350**: h440.

25 Feldman DE, Bernatsky S, Lévesque JF, Van MT, Houde M, April KT. Access and perceived need for physical and occupational therapy in chronic arthritis. *Disabil Rehabil*. 2010; **32**: 1827-32.

Table 1 Baseline characteristics of the participants by SES quartiles

	Quartile 1† (n = 269)	Quartile 2 (n = 267)	Quartile 3 (n = 268)	Quartile 4 (n = 268)	P value
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Age (years)	63.7 (7.7)	63.3 (7.7)	62.4 (7.3)	62.8 (7.4)	**0.047**
Sex (Women: %)	56	50	52	47	0.19
BMI (kg/m^2)	28.8 (4.9)	27.4 (4.6)	28.0 (4.5)	27.3 (4.7)	**<0.001**
Incidence of THR (%)	6	4	5	5	0.19
Incidence of TKR (%)	8	6	7	7	0.22
Time to THR (years) (median, IQR)	12.6 (12.1–13.8)	13.0 (12.3-14.1)	12.9 (12.2-13.9)	12.9 (12.3-13.9)	0.45
Time to TKR (years) (median, IQR)	12.6 (12.1–13.8)	12.9 (12.2-14.0)	12.9 (12.2-13.9)	12.9 (12.3-13.9)	0.61
Hospital performed THR, (Private: %)	**67**	**92**	**93**	**100**	**0.03**
Hospital performed TKR, (Private: %)	82	79	91	85	0.659
Prevalence of Hip ROA (%)	47	45	42	45	0.948

Prevalence of Knee ROA (%)	70	68	67	67	**0.04**
Prevalence of Hip pain (%)	53	44	33	37	**<0.001**
WOMAC knee pain‡	5.6 (8.0)	3.7 (6.7)	3.2 (5.2)	2.5 (4.6)	**<0.001**
Prevalence of comorbidities	82	74	70	69	**0.02**

Student's T-test or X^2 test (proportions) used. BMI – body mass index, THR – total hip replacements, TKR – total knee replacements, IQR – inter-quartile range, ROA – radiographic osteoarthritis, WOMAC - Western Ontario McMaster Osteoarthritis Index; † Quartile 1 represents the most disadvantaged group, ‡ Range: 0-45. Significant differences between groups shown in Bold.

Table 2 Associations between socio-economic status quartiles with the time to total hip replacements over 12 years

	Unadjusted (n=1068)		†Adjusted (n=1068)		††Adjusted (n=978)	
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Quartile 1*	Ref		Ref		Ref	
Quartile 2	0.45	(0.20, 1.05)	0.46	(0.20, 1.05)	0.45	(0.19, 1.06)
Quartile 3	0.54	(0.26, 1.12)	0.55	(0.26, 1.14)	0.59	(0.27, 1.31)
Quartile 4	0.65	(0.31, 1.36)	0.68	(0.32, 1.43)	0.74	(0.33, 1.65)
P for trend		0.316		0.367		0.537

* Quartile 1 represents the most socioeconomically disadvantaged group.

†Adjusted for age, sex, BMI. ††Further adjusted for presence of hip pain and hip radiographic osteoarthritis. HR = Hazard Ratio.

Table 3 Associations between socio-economic status quartiles with the time to total knee replacements over 12 years

	Unadjusted (n=1072)		†Adjusted (n=1072)		††Adjusted (n=993)	
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Quartile 1*	Ref		Ref		Ref	
Quartile 2	0.63	(0.33, 1.21)	0.75	(0.20, 1.05)	0.80	(0.38, 1.68)
Quartile 3	0.75	(0.39, 1.47)	0.85	(0.26, 1.14)	0.91	(0.43, 1.94)
Quartile 4	0.91	(0.49, 1.66)	1.13	(0.32, 1.43)	1.48	(0.75, 2.93)
P for trend		0.877		0.704		0.315

* Quartile 1 represents the most socioeconomically disadvantaged group.

†Adjusted for age, sex, BMI. ††Further adjusted for Western Ontario McMaster Universities Osteoarthritis Index pain and knee radiographic osteoarthritis. HR = Hazard Ratio.

Table 4 Associations between socio-economic status quartiles with the time to total hip replacements over 12 years

	Unadjusted (n=1068)		†Adjusted (n=1068)		††Adjusted (n=978)	
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Quartile 1*	Ref		Ref		Ref	
Quartile 2,3 & 4	**0.55**	**(0.31, 0.98)**	*0.56*	*(0.32, 1.00)*	0.59	(0.32, 1.09)

* Quartile 1 represents the most socioeconomically disadvantaged group.

†Adjusted for age, sex, BMI. ††Further adjusted for presence of hip pain and hip radiographic osteoarthritis. Statistical significance ($p<0.05$) shown in Bold. P value = 0.05, shown in *Italics*. HR = Hazard Ratio.

Table 5 Associations between socio-economic status quartiles with the time to total knee replacements over 12 years

	Unadjusted (n=1072)		†Adjusted (n=1072)		††Adjusted (n=993)	
	HR	(95% CI)	HR	(95% CI)	HR	(95% CI)
Quartile 1*	Ref		Ref		Ref	
Quartile 2,3 & 4	0.76	(0.46, 1.27)	0.90	(0.53, 1.54)	1.01	(0.57, 1.82)

* Quartile 1 represents the most socioeconomically disadvantaged group.

†Adjusted for age, sex, BMI. ††Further adjusted for Western Ontario McMaster Universities.

Osteoarthritis Index pain and knee radiographic osteoarthritis. HR = Hazard Ratio.